DISPOSAL OF OLD PAINT

6-8

SUBJECT:
Chemistry, Drama

TIME:
3 class periods

MATERIALS:
video camera, if desired
camera for slides or pictures, if desired
microphone
pictures of toxic products and landfills
student sheet

OBJECTIVES

The student will do the following:

1. Identify toxic household products that should not be disposed of in a landfill.
2. Select alternative disposal procedures involving toxic products.
3. Write a news program for a local TV station explaining and identifying toxic substances that should not be placed in a landfill.

BACKGROUND INFORMATION

Our society produces immense quantities of waste. According to estimates by the U.S. Environmental Protection Agency (EPA), our society produces over ten billion tons of waste per year. This quantity comes not only from municipal waste but from agriculture, mining, and industry. According to U.S. EPA figures from the 1990s, about 180 million tons of municipal waste are produced each year in the U.S. Without source reduction, the EPA estimates that U.S. citizens will generate approximately 216 million tons of municipal waste in the year 2000.

Waste volumes are growing even faster than our population. The U.S. produces about four pounds per person per day of municipal solid waste in the late 1990s, up from about 3.5 pounds per person per day in 1960. This is projected to be about 5 pounds per person per day in the year 2000.

Of major concern is groundwater pollution. Pollutants in waste can cause health and environmental problems if allowed to enter the groundwater, which is used for drinking by 70 percent of the nation. Chemical reactions during the degradation of material in a landfill can allow pollutants such as metals to become soluble and to migrate, if not contained, into surrounding water supplies. Today’s landfill designs seek to contain these waste materials and to monitor the groundwater to ensure that containment is secure.

Terms

landfill: a large, outdoor area for waste disposal; landfills where waste is exposed to the atmosphere (open dumps) are now illegal; in “sanitary” landfills, waste is layered and covered with soil.

toxic: having the characteristic of causing death or damage to humans, animals, or plants; poisonous.

ADVANCE PREPARATION

A. Make arrangements to use a video camera to tape the news program.

B. Create a news station atmosphere.

PROCEDURE

I. Setting the stage

A. Show a video depicting hazardous products and materials.

B. Discuss problems with storing toxic products in a landfill.

C. Discuss alternative disposal of hazardous materials.

II. Activity

A. Divide the students into groups. Each team will represent a different TV station news team.

B. Have students choose who will be the interviewer and who will be interviewed.

C. Have student choose two anchor people.

D. Have students choose reporters.

E. Have each team practice, then present its news report.

III. Follow-Up

A. Ask the students to determine what constitutes a “good” news report, thereby establishing “criteria” for “evaluation.” Introduce them to these concepts.

B. Using their criteria, have the students vote on the best news report in the class.

IV. Extensions

A. Have students determine the availability of toxic product disposal in their communities. For example, where can used motor oil be recycled to prevent it from reaching landfills and polluting groundwater?

B. Have the students call oil-changing stations or service stations to find out how they dispose of their used oil.

RESOURCE

American Water Works Association, <u>Household Hazardous Waste Brochure</u>, West Quincy Avenue, Denver, CO 80235.

<u>Earth Science</u>, Prentice Hall, 1991.

LFG Control and Recovery, by author: SCS Engineers, http://204.240.184.66/landfill.html

Solid Waste Landfills: http://wissago.uwex.edu/uwex/course/landfill/

POTENTIAL SOURCES OF GROUNDWATER CONTAMINATION

Source	Possible Major Contaminants
Landfills	
Municipal	Heavy metals, chloride, sodium, calcium
Industrial	Wide variety of organic and inorganic constituents
Hazardous waste disposal sites	Wide variety of inorganic constituents (particularly heavy metals such as hexavalent chromium) and organic compounds (pesticides, solvents, PCBs)
Liquid waste storage ponds (lagoons, leaching ponds, and evaporation basins)	Heavy metals, solvents, and brines
Septic tanks and leach fields	Organic compounds (solvents), nitrates, sulfates, sodium, and microbiological contaminants
Deep-well waste injection	Variety of organic and inorganic compounds
Agricultural activities	Nitrates,herbicides, and pesticides
Land application of wastewater and sludges	Heavy metals, organic compounds, inorganic compounds, and microbiological contaminants
Infiltration of urban runoff	Inorganic compounds, heavy metals, and petroleum products
Deicing activities (control of snow and ice on roads)	Chlorides, sodium, and calcium
Radioactive wastes	Radioactivity from strontium, tritium, and other radionuclides
Improperly abandoned wells and exploration holes	Variety of organic, inorganic, and microbiological contaminants from surface runoff and other contaminated aquifers

CONTAMINATION OF GROUNDWATER

6-8

SUBJECTS:
Earth Science, Geology

TIME:
50 minutes

MATERIALS:
clear plastic boxes
clay
water
student sheet
teacher sheet

OBJECTIVES

The student will do the following:

1. Demonstrate how precipitation on a farming field or nursery can leak chemicals into groundwater, contaminating wells, ponds, and streams.

2. List safe and unsafe farming methods.

BACKGROUND INFORMATION

Almost all groundwater is formed by the downward percolation of precipitation through the zone of aeration. Small amounts of groundwater also originate from seawater trapped in rocks when they were deposited (known as connate water).

The distribution of water can be split into four zones. The soil zone and the intermediate zone form the unsaturated zone of aeration which contains soil moisture and air in pores or voids (interstices) between the soil particles. Water pressure is lower than atmospheric pressure due to capillary forces. The capillary fringe forms the zone of movement and, together with the underlying aquifer, form the zone of saturation. The most significant quantity of water is held in the aquifer where nearly all the interstices are full of water.

The underground storage of water can be considered in terms of changes in storage, recharge, and discharge. The change in storage equals the recharge minus the discharge. Thus, the groundwater balance can be represented as:

D S (storage) = Q_r (recharge) - Q_d (discharge)

Recharge occurs by infiltration and subsequent percolation of water as the result of a precipitation event.

River channels include influent and effluent streams. Influent channels occur when groundwater is discharged into the river channel. Effluent channels occur when river channels and lakes in contact with the groundwater body discharge water to the underlying aquifer.

The movement of groundwater is dependent upon the slope of the water table (or hydraulic gradient) of the aquifer. Other physical factors also affect groundwater movement, such as the geology (type of sand and gravel, mineral deposits, etc.).

Wetlands often act as links between ground and surface water. After a rainstorm, wetlands act as catchment basins. If the wetland is located above the water table and its underlying soil allows water movement, water will gradually move from the wetland into the underlying soil. If wetlands are drained, the water which would normally enter the groundwater supply is likely to remain above ground, leading to erosion, sedimentation, and flooding of lakes and rivers.

Terms

groundwater: water that infiltrates into the Earth and is stored in usable amounts in the soil and rock below the Earth's surface; water within the zone of saturation.

precipitation: water droplets or ice particles condensed from atmospheric water vapor and sufficiently massive to fall to the Earth's surface, such as rain or snow.

runoff: water (originating as precipitation) that flows across surfaces rather than soaking in; eventually enters a water body; may pick up and carry a variety of pollutants.

ADVANCE PREPARATION

A. Have on hand clear plastic boxes, water, and clay.

B. Divide students into groups.

PROCEDURE

I. Setting the stage

A. Show a video of groundwater pollution.

B. Gather pictures that explain groundwater leaching and discuss how what we place in the soil can eventually leak into groundwater.

II. Activity

A. Have students put clay in the clear plastic box, making one end a sloping hill that drains into a pond. Be sure the ridges in the clay cause the water to drain into the pond area when poured into the clear box.

B. Have students change the ridges in the clay so the water does not drain into the pond.

C. Have them compare the results of the two activities.

III. Follow-Up

A. Discuss what happened in each setup and why.

B. Relate the direction of plowing to the runoff that occurs into bodies of water.

C. Ask students to recall farms and how they were plowed with respect to the land.

IV. Extensions

A. Students can create a poster show that depicts groundwater contamination.

B. Have students explain the relationships between surface and groundwater that might exist over the four seasons of the year.

C. Visit an area where wetlands contain water or where storm water detention ponds exist. Test the water for contamination (Examples: solids, pH).

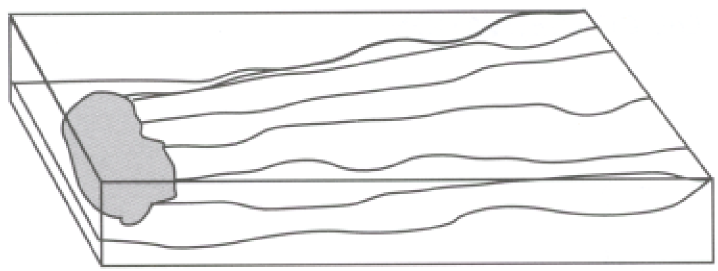
RESOURCES

Earth Science, Prentice Hall, 1991.

Groundwater video. Obtain through the Water Environment Federation, 601 Wythe Street, Alexandria, VA 22314-1994 (phone: 703-684-2400, FAX: 703-684-2492, or http://www.wef.org)

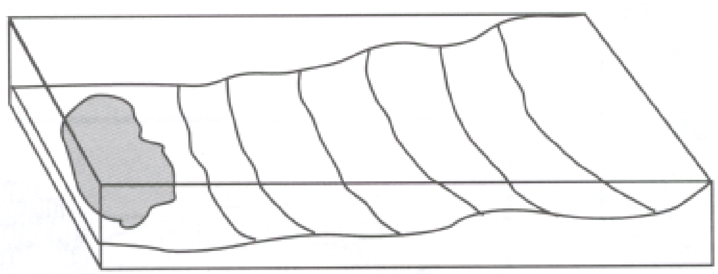
Groundwater: http://giswww.king.ac.uk/aquaweb/main/groundwa/gw1.html

Water Purification Capabilities: http://hermes.ecn.purdue.edu:8001/http_dir/Gopher/agen/agen521/Lessons/Wetlands/purification.html



Hill w/ ridges that drain into pond

Set-Up A



Contour plowing

Set-Up B

1. What did you observe in A?

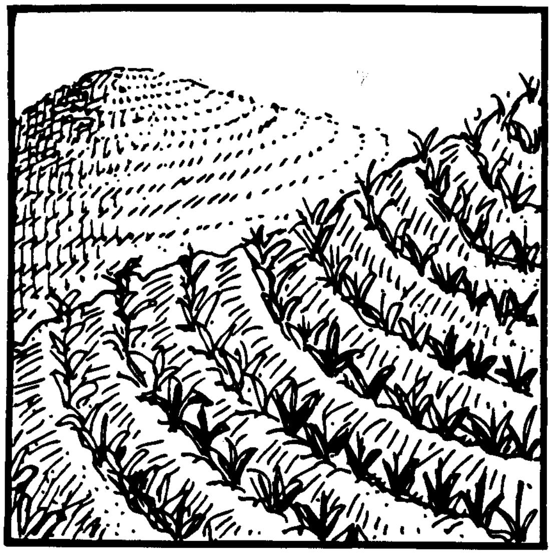
2. What did you observe in B?

3. How does plowing affect erosion?

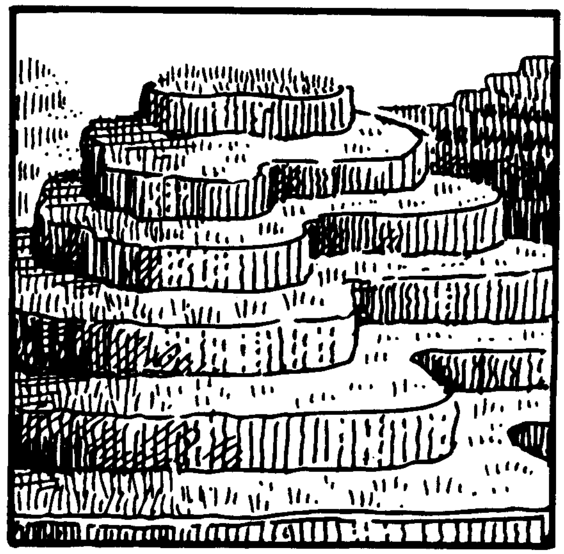
4. How can groundwater be contaminated by poor farming practices?

SOIL CONSERVATION

CONTOUR FARMING



TERRACING



WINDBREAK

GROUNDWATER

6-8

SUBJECTS:
Chemistry, Geology

TIME:
50 minutes

MATERIALS:
oblong balloon
plastic box
sand
gravel
plastic cup
straight pin
teacher sheets

OBJECTIVES

The student will do the following:

1. Define groundwater.

2. Identify groundwater's relationship to springs, artesian wells, ordinary wells, and sinkholes.

3. Explain the process by which sinkholes are formed.

4. Explain saltwater contamination and explain its causes.

BACKGROUND INFORMATION

Sinkholes form in carbonate terraces when acidic groundwater dissolves the underlying rock. They are typically closed depressions, in which water drains down into the underlying rock rather than over a surface stream or gully. Sinkholes are common in a type of topography called karst, which is characterized by abundant sinkholes, caves, springs, and disappearing streams. Although common in many parts of the world, such as the Southeastern United States, karst is uncommon in the western United States.

Sinkholes, caves, and other karst features form when carbonate rock dissolves in acidic groundwater. Normal rainwater becomes acidic as it percolates through the soil and picks up carbon dioxide (CO_2) produced by organisms in the soil. The CO_2 dissolves in the water and forms carbonic acid: $CO_2 + H_2O = H_2CO_3$ (carbonic acid), which disassociates into a hydrogen cation and bicarbonate anion to form carbonic acid:

$H_2CO_3 = H^+ + HCO_3^-$ (bicarbonate anion)

The hydrogen of the carbonic acid then attacks the calcium carbonate of which the marble is composed:

$CaCO_3$ (calcium carbonate) $+ 2H^+ = Ca^{++} + 2HCO_3^-$

(The two +'s near the Ca refer to the double positive charge of the Ca ion.) The Ca^{++} and HCO_3^- ions then flow away in the groundwater.

This process can form underground caves and passageways. If one of these underground cavities collapse, a sinkhole forms. Groundwater flows along joints and fractures dissolving the marble and forming sinkholes, caves, and other karst features. With time, the joints and fractures widen and turn into cracks and canyons.

<u>Terms</u>

artesian well: a well in which the water comes from a confined aquifer and is under pressure. One type of artesian well is a **free-flowing artesian well** where water just flows or bubbles out of the ground without being pumped.

drought: a lack of rain or water; a long period of dry weather.

groundwater: water that infiltrates into the Earth and is stored in usable amounts in the soil and rock below the Earth's surface; water within the zone of saturation.

karst: topography formed mainly by underground drainage characterized by sinkholes, caves, springs, and disappearing streams.

percolate: to drain or seep through a porous substance.

saline (or saltwater) intrusion: the saltwater infiltration of freshwater aquifers in coastal areas, when groundwater is withdrawn faster than it is being recharged.

sinkhole: a natural depression in a land surface connected to a subterranean passage, generally occurring in limestone regions and formed by solution or by collapse of a cavern roof.

ADVANCE PREPARATION

A. Gather all materials before hand so they are ready for the activity.

B. Have on hand enough sand for everyone to build boxes.

PROCEDURE

I. Setting the stage

A. Show the students a bag of sand, soil, and gravel. Ask them to describe each.

B. Fill a plastic box with gravel first, then soil, and finally sand. Discuss the fact that all make up the surface of the Earth. (Have students observe the layers.)

C. Explain and illustrate how water moves from the Earth's surface to underground. Explain and discuss springs.

D. Talk about the removal of water from underground for our use.

II. Activity

A. Have each student cover bottom of the box with about 2 1/2 inches each of gravel, soil, and sand (top).

B. Blow up and tie the balloon. Place it in the center of the box on top of the sand.

C. Cover the balloon by placing sand over it, packing the balloon down.

D. Put a paper cup on top of the sand that is over the balloon.

E. Use your straight pin to burst the balloon. The results will illustrate how sinkholes are formed.

III. Follow-Up

A. Have students use the scientific method to write up the activity.

B. Have students discuss in writing the importance of groundwater.

C. Have students illustrate what was observed in the activity.

D. Have students explain the relationship between groundwater and sinkholes.

IV. Extensions

A. Go to the library and research sinkholes. Find out if you live near an area where sinkholes occur.

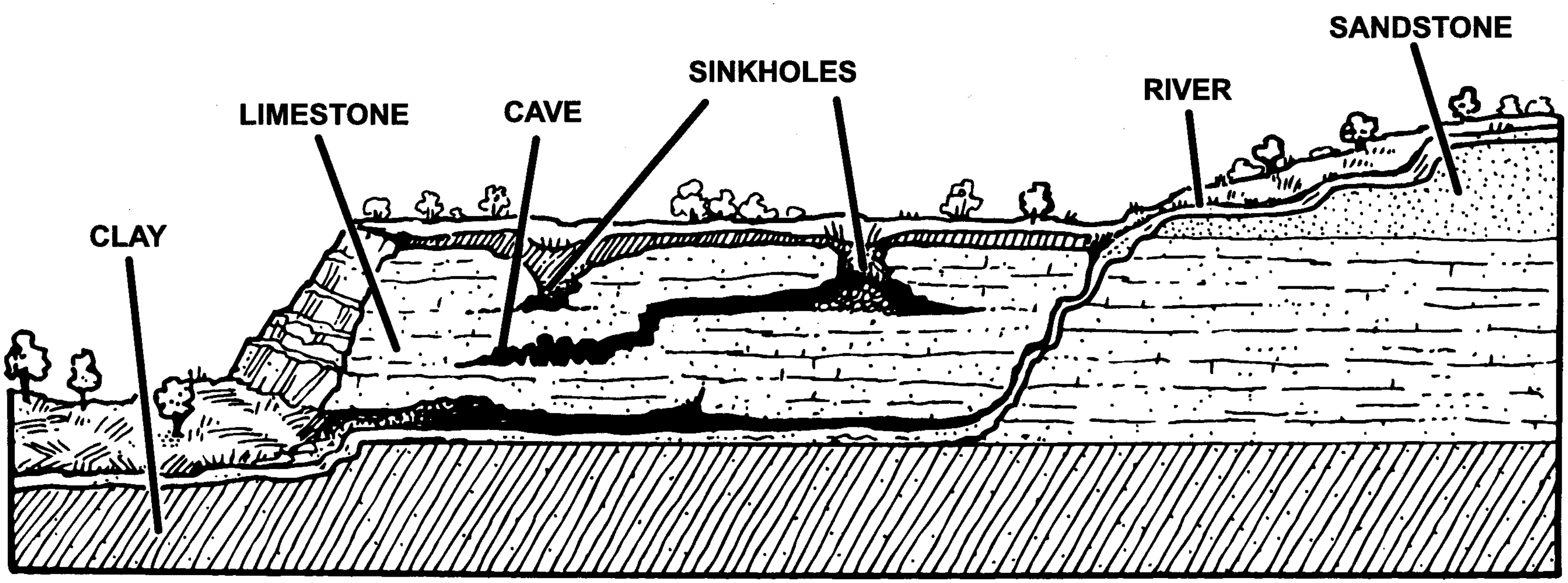
B. If you have a chance, plan a field trip to the nearest sinkhole. Remember: some plants and animals may live only in this one place. Therefore, try to protect their habitat. Stay on marked trails. Try to leave no evidence of your visit—only your footprints.

C. Obtain a piece of limestone and some carbolic acid. Put the acid on the stone and observe how it dissolves the limestone.

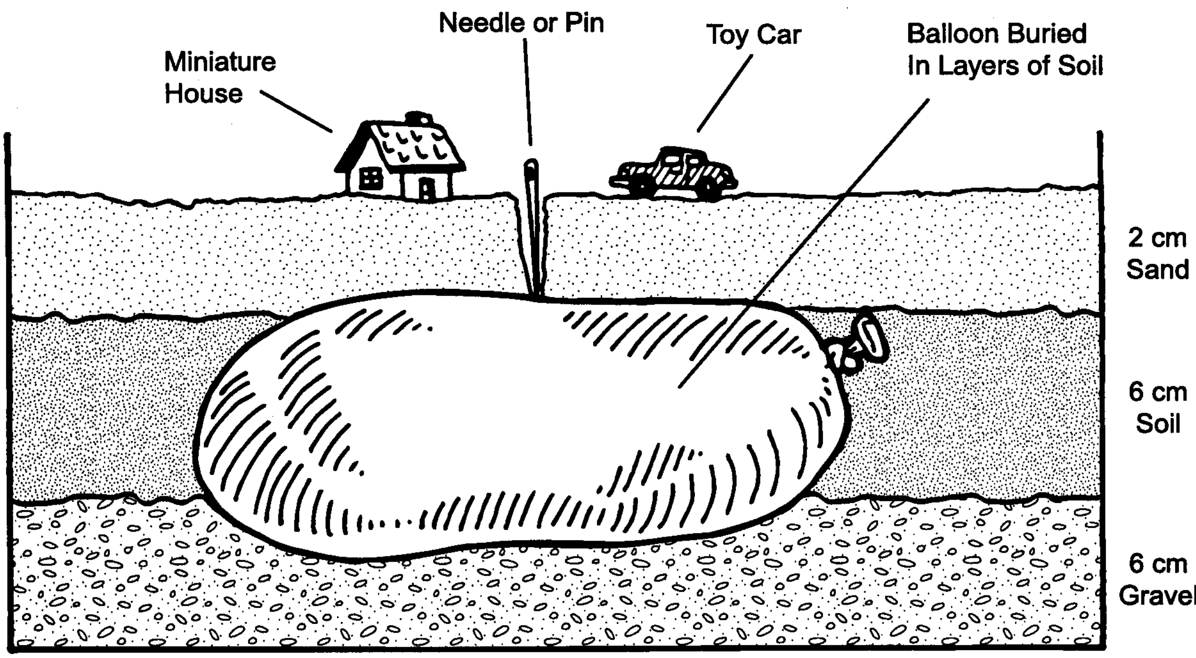
RESOURCES

Environmental Science, Teacher's Edition, Holt, Rinehart and Winston, 1996.

Sinkhole: http://emerald.ucsc.edu/~es10/fieldtripUCSC/sinkhole.html


SANDSTONE
RIVER
SINKHOLES
CAVE
LIMESTONE
CLAY

A MODEL KARST FORMATION



INVISIBLE WATER

6-8

SUBJECTS:
Art, Earth Science, Math

TIME:
50 minutes

MATERIALS:
a large display relief map of the world
a 12-inch diameter globe (one showing the ocean bottom is best)
a five or ten gallon aquarium
writing materials
calculators
measuring cup
one quart container for every three students

OBJECTIVES

The student will do the following:

1. Define groundwater, aquifer, and hydrologic cycle or water cycle.
2. Describe the amount and distribution of groundwater on planet Earth.
3. Make inferences about the importance of responsible use of groundwater.
4. Calculate water volumes using the statistical information provided.

BACKGROUND INFORMATION

The Earth has been called the water planet. Between two-thirds and three-fourths of the Earth's surface is water, which is visible in rivers, ponds, lakes, icecaps, and clouds. The Earth's invisible source of water (groundwater) is more difficult to see and understand, yet all these forms of water are part of the interrelated flow of water that we call the water cycle or hydrologic cycle.

Water, a renewable natural resource, is continuously being renewed through the hydrologic or water cycle. The hydrologic cycle is powered by the sun's energy and gravity. In this circulation process, water is constantly in motion, cycling through sky, earth, and oceans.

When precipitation (snow, sleet, rain, or hail) falls on the Earth's surface, several things may occur. When precipitation builds up on the soil surface, surface runoff occurs. Surface water moves by overland flow into stream, ponds, lakes, or other bodies of water. When precipitation falls on a porous soil surface, some of the water will seep into the ground through infiltration. Some water clings to soil particles and is drawn into the roots of growing plants; it is then transported to leaves, where it is lost to the atmosphere as vapor in the transpiration process.

Some of the water that enters the soil moves either laterally or vertically through the soil. Lateral movement of water through the soil is called throughflow or interflow. Vertical or downward movement of water through the soil is called percolation. The percolating water eventually enters the zone of saturation, where all spaces between the rocks and soil particles are filled with water. The water filling all the spaces between the rocks and soil particles in the saturated zone is known as groundwater.

Groundwater is stored in two geologic regions: aquitards or aquifers. If water cannot move through the particles of the geologic region, the region is called an aquitard. If water can move through or permeate through the material of the geologic region, the region is called an aquifer.

Aquitards and aquifers vary in their depth, thickness, and even where they occur. An aquifer that is bounded on the top and bottom by aquitards is known as a confined aquifer. Generally, unconfined aquifers are overlaid by permeable layers and are usually found near the land surface.

Groundwater flows through the rocks and layers of earth until it discharges in springs, streams as baseflow, and oceans. The sun warms up the water surface, changing water into vapor, a process known as evaporation.

Each of the segments of the water cycle shares a portion of the total amount of the water on planet Earth. Fresh water is not evenly distributed throughout the world. Some people take fresh, clean water for granted, while others treasure every drop. Yet, simple calculations demonstrate the fact that the amount of water is limited. Scientists believe that all the water that we will ever have is on the Earth right now. Whatever amount is available for human and animal consumption depends on how the quality is maintained. We, as human beings, have the responsibility to conserve water and use it wisely while protecting its quality.

The purpose of this activity is for students to understand how fragile and important water is as a natural resource.

Terms

aquifer: an underground layer of unconsolidated (porous) rock or soil that holds (is saturated with) usable amounts of water.

aquitard: an underground layer of consolidated (nonporous) rock or impermeable soil through which water cannot move.

baseflow: groundwater contribution to a stream.

confined aquifer: an aquifer that is sandwiched between two layers of impermeable materials and is under great pressure.

evaporation: conversion of a liquid to the vapor state by the addition of heat.

groundwater supply: the amount of fresh water stored beneath the Earth's surface.

infiltration: when precipitation falls on a porous soil surface and some of the water seeps into the ground.

interflow: significant lateral movement of water through the soil.

overland flow: when precipitation moves quickly over the surface of the land into a stream channel or other body of water.

percolation: downward movement of water through the soil.

precipitation: any or all of the forms of water particles, whether liquid or solid, that fall from the atmosphere and reach the ground.

surface runoff: when precipitation builds up on the soil surface and water moves by over land flow into a stream channel or other body of water.

throughflow: significant lateral movement of water through the soil.

transpiration: the passage of water from plants and animals directly into the air in the form of a vapor.

unconfined aquifer: an aquifer overlaid by permeable layers, generally found near the Earth's surface.

water cycle: the cyclical process of water's movement from the atmosphere, its inflow and temporary storage on and in land, and its outflow to the oceans. The cycle consists of three principal phases: precipitation, runoff in surface waters or groundwater, and evaporation and / or transpiration in the air.

zone of saturation: that region below the surface in which all voids are filled with liquid.

ADVANCE PREPARATION

A. Have students make a panel mural of the water or hydrologic cycle, emphasizing the location of groundwater.

B. Make transparencies of the hydrologic or water cycle and the relative percentages of water on Earth.

C. Make a student facts sheet showing the percentages of water locations on Earth.

PROCEDURE

I. Setting the stage

A. Introduce the unit with a film on groundwater or groundwater resources.

B. Have students read and identify the terms used in the background information.

II. Activity

A. Using a relief map of the Earth and the transparency of relative percentages of water on Earth, begin the discussion by pointing out that groundwater is less than 1% of the total amount of water on the Earth. Relate this fact to the percentage of ocean water that is between two-thirds and three-fourths of the surface of the Earth.

B. Discuss the relative percentages.

C. Provide students with a facts sheet. Have the students calculate the estimated amount of fresh water potentially available for human use:

Groundwater	0.62%
Freshwater lakes	0.009%
Rivers	0.0001%
Icecaps/glaciers	2.0%
	2.6291%

D. While discussing the relative percentages of freshwater, emphasize that the usable percentage of existing fresh water is reduced by pollution and contamination, the fact that all groundwater is not available, and the fact that water from icecaps is not readily available.

E. Ask the students to discuss the following:

1. The amount of water used by humans daily for drinking, food preparation, bathing, laundry, and recreation.

2. That other life forms (plant and animal) need fresh, clean water as well as saline (salt) water.

F. Have the students assume that five gallons (or 1280 tablespoons) represents all the water on Earth. Have the students calculate the volume of all the quantities on the water percentage list. Ask the students to consider the following:

1. Remind students hat for multiplication, all the decimal places must be shifted two places to the left so 97.2% becomes 0.972 prior to multiplication:

Example: 0.972 X 1280 tablespoons = 1244.16 tablespoons

VOLUME OF WATER ON THE WATER PERCENTAGE LIST

5 gallons		1280.00	
Oceans		1244.16	
Icecaps/glaciers		26.24	
Groundwater		7.93	
Freshwater lakes		0.11	
Inland seas/salt lakes		0.1	
Atmosphere		0.0128	
Rivers		0.0012	
	approx.	1280.0000	Tablespoons

2. Once the values are obtained, ask the students to calculate the total volume of all water other than ocean water. (It is approximately 34 tablespoons.)

3. Explain to the students that the volume of water on the water percentage list will be used in the science class.

G. SCIENCE CLASS:

1. Have students make a data table using the volume of water on the water percentage list that was completed earlier in mathematics, being sure to show the total volume of water other than saline water.

2. Once the values are placed on the data table, divide the students into teams of three. Have the gopher for each team place 34 tablespoons of water in a container and take it to the team's workstation.

3. Ask students to remove the amount of water representing all freshwater lakes (approximately 0.11 tablespoon).

4. Ask students to remove the amount of water representing all the rivers (approximately 0.001 tablespoon, which is less than a drop).

5. Ask students to remove the amount of water representing all groundwater (approximately 7.9 tablespoons).

6. Have the students discuss the following:

    a. The fragile nature of the freshwaters (especially groundwater), wetlands, and oceans of our planet.

    b. The vast number of species (both plant and animal) that are dependent on clean, usable groundwater for survival.

    c. How fresh water is replenished by the water cycle (Example: by evaporation from the snows and inland rainfall that recharges streams and aquifers).

III. Follow-Up

A. Present the film Groundwater. Have students draw and label typical soil profiles.

IV. Extensions

A. Have students find our where the local drinking water supply is obtained by calling the city or county water supply department. Research the number of wells in the area: Hown many are there? How deep is the average well? What are the most common minerals and compounds in the water? Does composition vary withlocale?

RESOURCES

Aquatic Project Wild, Western Regional Environmental Education Council, 1987. Obtain from Aquatic WILD, PO Box 18060, Boulder, CO 80308-8060 (phone: 303- 444-2390).

Coble, Rice, Walla, Murry, et al. Earth Science, Prentice Hall, Englewood Cliffs, NJ; Needham, MA, 1994.

Groundwater video. Obtain through the Water Environment Federation, 601 Wythe Street, Alexandria, VA 22314-1994 (phone: 703-684-2400, FAX: 703-684-2492, or http://www.wef.org).

PERCOLATION

6-8

SUBJECT:
Geology

TIME:
30 minutes

MATERIALS:
aquarium or ant farm type glass case
clean sand (white or yellow)
water
food coloring
dish detergent bottle or similar one with a nozzle
student sheet

OBJECTIVES

The student will do the following:

1. Observe how water travels through soil over a short period of time.

2. Learn that the movement of water through soil can carry surface contamination to deeper levels (including groundwater).

3. Predict how they believe the water will travel through the soil.

BACKGROUND INFORMATION

During precipitation, water reaching the ground will infiltrate into the underlying soil. Water that is not taken up by plant roots can percolate through the ground to join the groundwater. The rate of percolation is dependent upon rock type and composition.

The infiltration capacity is the constant rate at which water percolates into the ground. Infiltration capacity is dependent upon soil porosity. Sandstones have high porosity and, therefore, high infiltration capacities while clays have low porosity and, therefore, low infiltration capacities.

Infiltration is measured using an infiltrometer.

<u>Terms:</u>

percolation: the drainage or seepage of a liquid through a porous substance.

leach: to remove soluble constituents by the actions of a percolating liquid.

point source: known source of contamination.

ADVANCE PREPARATION

A. Prior to the lesson, pack the sand tightly and uniformly in the glass case. (An ant farm case will work best because it will be easier to see the movement of the water through the sand; however, be sure it is sealed so that it will not leak.) Prepare the colored water in the bottle.

PROCEDURE

I. Setting the stage

A. Discuss the topic of percolation and explain how it can carry contamination to deeper levels of the soil and to the groundwater. Explain what a point source of contamination would be.

II. Activities

A. Have the students guess how they think the water will move through the soil and sketch a picture of it.

B. Place the glass case so that all the students can see it.

C. Add the water. If using an aquarium, add the water near the front edge so that all students can see it. Make sure to put the water in one location. Do not move the bottle as it is added. This will illustrate a point source contamination.

D. Observe the way the water moves through the sand.

III. Follow-Up

A. Have the students compare their guesses (either orally or written) as to what actually happened.

IV. Extensions

A. Use sand with a different grain size and try the experiment again. Or, use clay as a layer with the sand. Demonstrate why liners are used for landfills.

RESOURCE

Groundwater: http://giswww.king.ac.uk/aquaweb/main/groundwa/gw1.html

Directions: Fill in the information as you do your investigation.

Soil Type	Estimated Percolation Time	Actual Percolation Time

1. Which soil was most porous?

2. Which soil was least porous?

3. How does percolation time affect groundwater?

4. How does percolation time affect leaching?

POROSITY? PERMEABILITY?

6-8

SUBJECTS:
Geology

TIME:
50 minutes

MATERIALS:
four 500 mL beakers
3 soil samples
water sample
stop watch
student sheet

OBJECTIVES

The student will do the following:

1. Define the terms porosity and permeability.

2. Explain the way water moves through the Earth.

3. Make a table in which to compile and interpret results.

BACKGROUND INFORMATION

Because of gravity, rainwater travels downward into the tiny openings in the Earth. These openings or spaces are called pores. The more porous the land, the greater the volume of water that the soil can hold. When you measure the volume of water the soil can hold, you are measuring the porosity.

Different soils let water pass through them at faster rates. This is called permeability. When you measure the time it takes for water to reach the bottom of the soil, the measure taken is the permeability of the soil. When all the pores of the soil are filled with water, the extra water makes its way down to lower levels. Eventually water begins to collect below the Earth's surface. This water is then called groundwater. Groundwater is liquid water that lies in the subsurface in fractures in rocks and in pore space between grains in sedimentary rocks. Groundwater is a type of freshwater that humans use for their everyday life.

Porosity is the percentage of open space in a rock. Porosity can be as high as 50 percent in loose sand to 5 percent in cemented, lithified sandstone, to near zero in unfractured igneous rocks. The porosity is due to pore spaces in the rock between the mineral grains. Compaction and cementation due to burial destroy porosity. Sediments may have up to 40 percent initial porosity before cementation.

Permeability is the ability of fluids to flow through rock, which depends on the connectivity of the pore space. Permeable rocks include sandstone and fractured igneous and metamorphic rocks and karst limestone. Impermeable rocks include shales and unfractured igneous and metamorphic rocks. The permeability depends on the communication of the pores in a rock. Permeability determines whether fluids such as gas, oil, or water can be produced from a reservoir. Rocks such as shales can have very good porosities (20 percent plus) but have very poor permeabilities. Permeability can be enhanced naturally due to fractures or can be stimulated artificially.

Natural cements form in the pore space between grains due to various chemical reactions. Common cements include calcite, hematite, dolomite, silica, and clay. Cementation of sedimentary rocks changes the ability of the rocks to contain fluids and the ability of fluids to move through the sedimentary rock.

<u>Terms</u>

gravity: the force of attraction, characterized by heaviness or weight, by which terrestrial bodies tend to fall toward the center of the Earth.

groundwater: water that infiltrates into the Earth and is stored in usable amounts in the soil and rock below the Earth's surface; water within the zone of saturation.

permeability: the property of a membrane or other material that permits a substance to pass through it.

porosity: the property of being porous, having pores; the ratio of minute channels or open spaces (pores) to the volume of solid matter.

ADVANCE PREPARATION

A. A day before the lab, gather sufficient materials for the class, assuming four students per group.

PROCEDURE

I. Setting the stage

A. Discuss with the class that porosity is the number of pore spaces in a given material. Stress that the more pore space in the soil, the more water the soil will hold.

B. Have the students read the lab.

1. Have the students make an educated guess as to which soil type will hold the most water. Why?

II. Activities

A. Divide the class into teams and have each group complete the following exploration.

1. Fill 3 beakers with 3 different soil types. Do not pack soil in the containers.

2. Write a hypothesis after looking at the three samples, predicting which sample will hold the greatest amount of water. Also predict which sample will cause the water to move through the fastest.

3. Fill the empty beaker with 75 mL of water. Slowly pour the water into the first soil sample. Stop when the sample can hold no more.

4. At the same time you are pouring the water, time with the stop watch how long it takes for the water to reach the bottom. Repeat steps 3 and 4 for the other two soil samples.

5. Use the table on the student sheet to record your data. Complete the table as you obtain your results.

III. Follow-Up

A. Have the students analyze the data, then answer the following questions.

1. Which soil had the greatest permeability?

2. Which soil had the least permeability?

3. Which soil held the most water?

4. Which soil held the least amount of water?

5. If your city was said to be the wettest city in the country, how would this affect the soil?

IV. Extension

A. Walk students around the school grounds discussing the different soil types that are seen.

1. On your walk, test presoaked permeability by using a coffee can with both ends cut off. Pour water into the can and time how long it takes the water to be absorbed into the ground. This presoaking will determine the initial filling of the soil space.

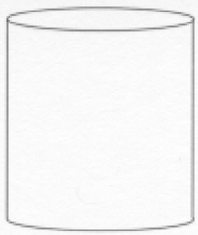
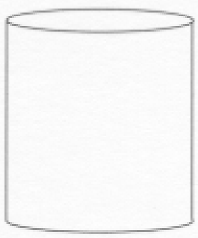
2. Wait five minutes after all the water has been absorbed. Pour the same amount of water into the can and time how long it takes the water to be absorbed into the ground. This will be the actual absorption rate after the soil space has been filled.

RESOURCES

Merrill, Focus on Earth Science, 1984.

Groundwater: http://xtl5.colorado.edu/~smyth/G101-12.html

University of Tulsa - Department of Geosciences, author: Sedimentary Rocks: http://arbuckle.utulsa.edu/epe/sed-rocks.html

Type of Soil	Time to Pass Through (in seconds)	Amount of Water Absorbed
 ____________		
 ____________		
 ____________		

1. _______________ had the greatest porosity.
2. _______________ had the least porosity.
3. _______________ had the greatest permeability.
4. _______________ had the least permeability.
5. _______________ held the most water.
6. _______________ held the least water.
7. What is the difference between porosity and permeability?

AQUIFERS AND RECHARGE AREAS

6-8

SUBJECTS:
Art, Geology

TIME:
50 minutes

MATERIALS:
3-liter soda bottle – demo
three large syringes
ruler
gravel
builder's sand
topsoil
measuring cup
water
food coloring
clear plastic cups (10 oz.)
student sheet
teacher sheets

OBJECTIVES

The student will do the following:

1. Create a model of an aquifer.
2. Describe how an aquifer works.
3. Describe how pumping affects an aquifer.
4. Prepare a model presenting to local planners the important aspects of protecting recharge areas.

BACKGROUND INFORMATION

An aquifer is a layer of underground rock or sand which stores and carries water. A recharge area is the place where water is able to seep into the ground and refill an aquifer because no confining layer is present. Recharge areas are necessary for a healthy aquifer. Few rules and regulations were made to protect these areas.

Aquifers form significant natural reservoirs of water and can form a large proportion of water used for drinking purposes. In some countries the supply of water from underground can be the only source of water available. The location and extent of aquifers is dependent upon the geological conditions of the underlying rock. There are three types of aquifers: perched, unconfined, and confined.

Perched aquifers occur in isolation as small quantities of water in suitable confining strata above the water table. Unconfined aquifers form when the permeable strata forms an outcrop on the surface. The upper part of the aquifer is represented by the water table whose levels fluctuate according to the groundwater balance. Confined aquifers have impermeable strata above and below and are not recharged by percolating rainwater.

Note that impermeable strata do not always represent a complete barrier to water movement and that recharge of the aquifer may take place many kilometers away where the strata forming the confined aquifer form a surface outcrop.

Terms

aquifer: an underground layer of unconsolidated rock or soil that is saturated with usable amounts of water (a zone of saturation).

recharge area: an area where water flows into the Earth to resupply a water body or an aquifer.

ADVANCE PREPARATION

A. Gather information from the city planning staff concerning a local recharge area that needs special protection from pollution and development.

B. Have the students visit the site and take pictures of the area.

C. After the trip have the students divide into groups of four.

PROCEDURE

I. Setting the stage

A. Tell the groups that they are going to conduct an experiment that includes creating an aquifer.

B. Explain what an aquifer is and the importance of a recharge area.

C. Brainstorm how this information will help us develop a plan to protect our recharge area.

II. Activities

A. Have each group mimic you as you:

1. Place 4 inches of gravel in a bowl. Measure correct amounts of gravel, topsoil, and sand with the ruler.

2. Put three syringes upright in the gravel. Do this before Step 3, or they will clog with sand. The syringes show an example of wells pumping from the aquifer.

3. Hold the syringes and at the same time put 3 inches of sand on top of the gravel and 2 inches of topsoil over the sand.

4. Add food coloring to 2 cups of water.

5. Slowly pour enough water over the topsoil to saturate. This is the example of rain seeping into the aquifer and becoming groundwater.

6. Put the bowl at eye level, observe, and record changes.

7. Pull the stopper up to fill one syringe. This is an example of how water well pumping affects the aquifer.

8. Repeat Step 6 using two syringes at once. Record changes in groundwater.

9. Repeat Step 6 again using all the syringes. Record changes in groundwater.

III. Follow-Up

A. Each group must answer the following questions:

1. Is this aquifer model a recharge area?

2. How do you know?

3. Describe how an aquifer works.

4. Are the sand and topsoil permeable or impermeable? Why?

5. What do you think would happen if more syringes were used?

6. Why is it necessary that we protect recharge areas?

IV. Extensions

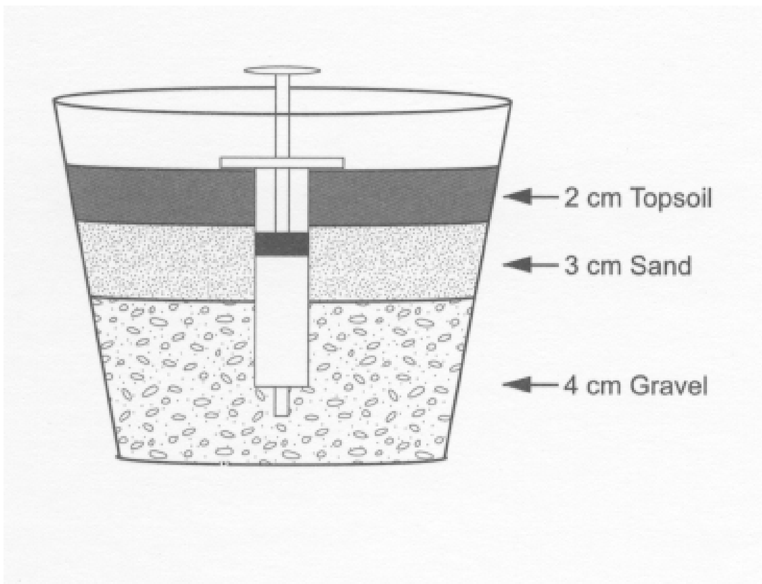
A. Each group should brainstorm ways to construct a model that they could present to the city planning committee. This model will show why this area needs protection. The model will show pictures of the site, the results of the experiments, and why a recharge area is important.

B. The winning group may present their model to the planning committee.

RESOURCES

Johnson Cynthia C., Waterways, Division of Public Information St. John's River Water Management District, Jacksonville, FL, 1991.

Groundwater: http://giswww.king.ac.uk/aquaweb/main/groundwa/gw1.html


2 cm Topsoil
3 cm Sand
4 cm Gravel

Directions: Draw your investigation set-up, record your observations, and answer the questions.

1. Fill the syringe 1/3 full. Record changes in groundwater.

2. Fill the syringe 2/3 full. Record changes in groundwater.

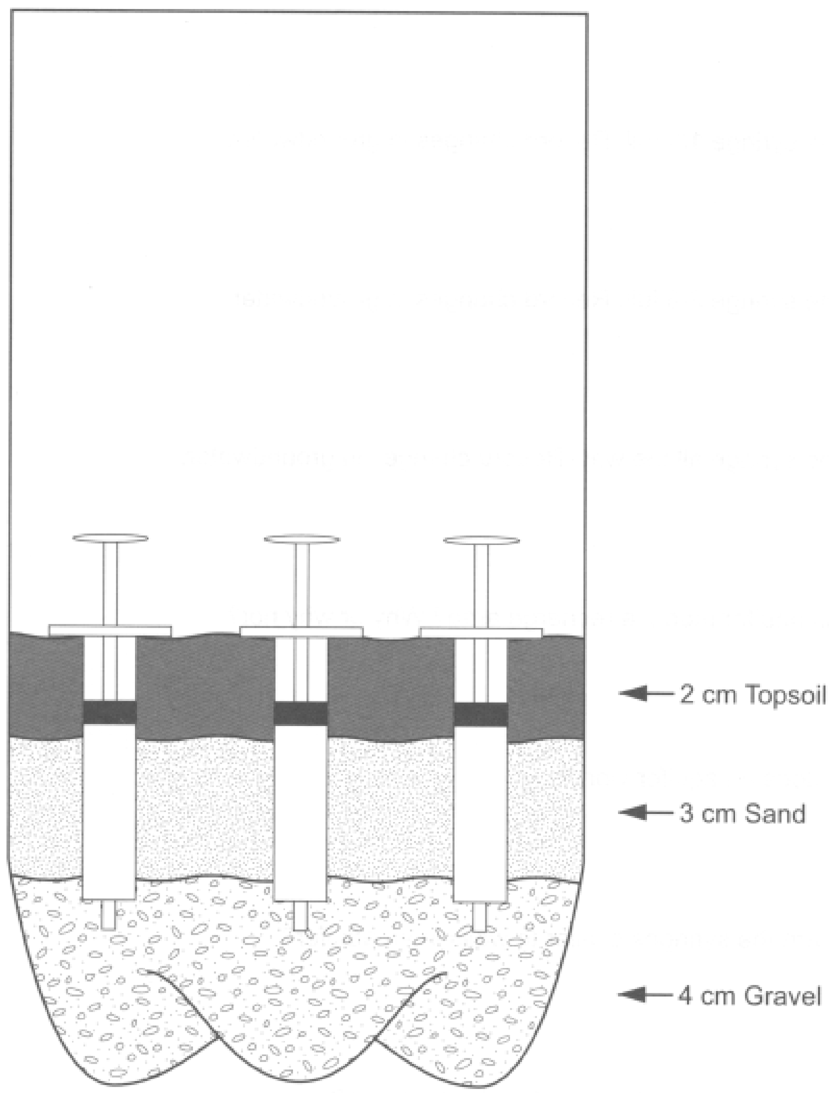
3. Fill the syringe all the way. Record changes in groundwater.

4. Is this aquifer model a recharge area? Why or why not?

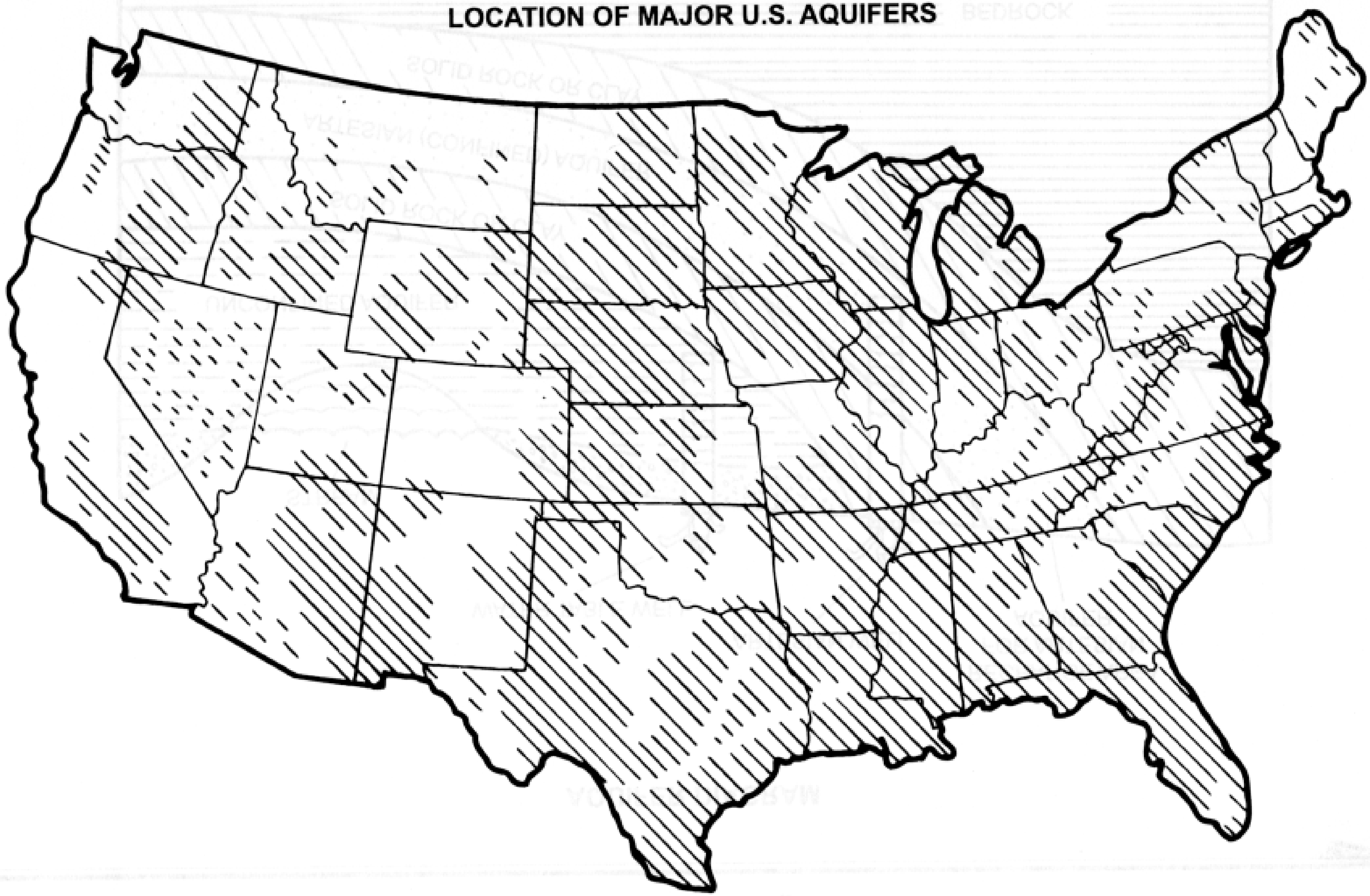
5. How does an aquifer work?

6. How are the syringes similar to wells in an aquifer?

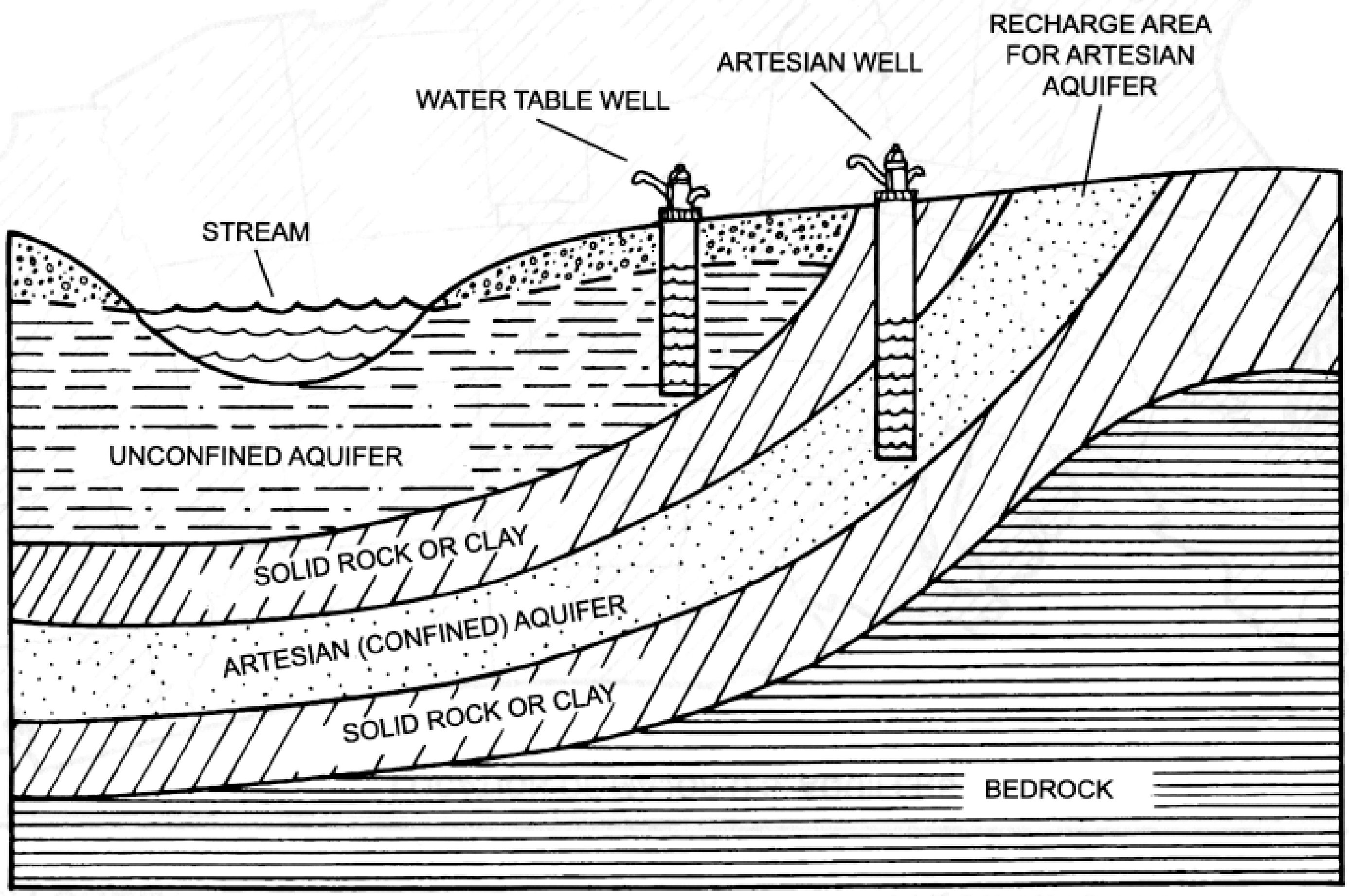
7. Why is it necessary to protect recharge areas?

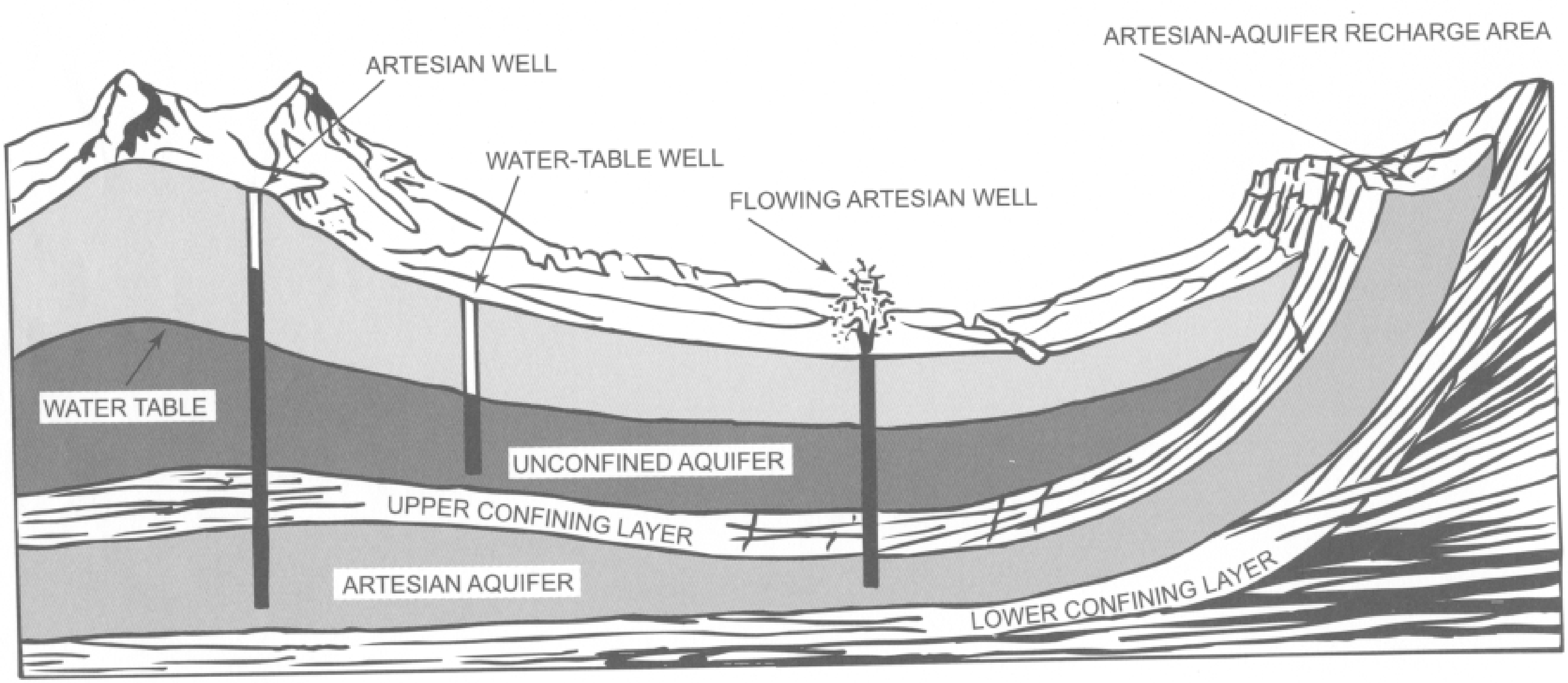

2 cm Topsoil
3 cm Sand
4 cm Gravel

LOCATION OF MAJOR U.S. AQUIFERS



AQUIFER DIAGRAM





The Groundwater Resource

WATER—THROUGH AND THROUGH

6-8

SUBJECTS:
Geology, Math, Language Arts

TIME:
2 class periods

MATERIALS:
pieces for rock samples
water
large beakers
triple beam balance
magnifying glass
student sheet

OBJECTIVES:

Students will be able to:

1. Observe rock samples of characteristics using the naked eye and magnifying glass.

2. Determine how much water different rock samples hold.

BACKGROUND

Each year worldwide 517,000 cubic kilometers of water are evaporated. About 108,000 cubic kilometers of water fall to the Earth as precipitation. What happens to this water? Some water is used by plants to survive. Some runs into lakes; most of the excess flows back into the ocean. The other is called groundwater since it sinks into the porous parts of the Earth's crust. Depending on the rock, water can pass through the layer or be trapped. These two layers are called impermeable and permeable.

Terms

aquifer: an underground layer of unconsolidated rock or soil that is saturated with usable amounts of water; a zone of saturation.

artesian well: a well in which the water comes from a confined aquifer and is under pressure. One type of artesian well is a **free-flowing artesian well** where water just flows or bubbles out of ground without being pumped.

impermeable: impassable; not permitting the passage of a fluid through it.

permeable: passable; allowing fluid to penetrate or pass through it.

porosity: the property of being porous, having pores; the ratio of minute channels or open spaces (pores) to the volume of solid matter.

ADVANCED PREPARATION:

A. Collect egg-sized pieces of rock samples (sandstone, shale, and other rocks).

B. Get the students thinking by displaying a jar filled with pebbles. Ask if the jar is full. (No, there are air spaces.)

C. Fill the jar with water to demonstrate.

PROCEDURE

I. Setting the stage

A. Discuss the concepts of permeable and impermeable rock.

B. Explain and discuss aquifers and wells.

II. Activity

A. Have students find and record the mass of each rock.

B. Have students soak the rocks in water overnight.

C. The next day, have the students remove the rocks from the water. Again ask them to find and record the mass of each sample.

D. Have students complete the student sheet.

III. Follow-up

A. Ask students to discuss the following questions:

   1. What information did you learn about each rock as it relates to the water?

   2. Which rock makes the best aquifer? The worst?

   3. How would water react to sand, clay, or coal?

IV. Extensions

A. Write a letter to the following organization to receive more information concerning geology:

   American Geophysical Union
   2000 Florida Ave. NW
   Washington, DC 20009
   http://www. AGU.org

B. Research local aquifers.

C. Have students discuss sinkholes and how they are related to aquifers.

D. Have students research where their local community drinking water originates.

RESOURCES

Hesser, D. and Leach, S., Focus on Earth Science, Merrill Publishing Company, Columbus, Ohio, 1987.

Cunningham, W. and Saigo, B., Environmental Science, 3rd Ed., William Brown Publishers, Dubuque, Iowa, 1995.

Directions: Fill in the data from your observations and answer the questions below.

Rock Sample	Mass Before Soaking	Mass After Soaking	Difference
1.			
2.			
3.			
4.			

1. What information did you learn about each rock as it relates to the water?

2. a. Which rock makes the best aquifer?_______________________________

   b. What rock makes the worst aquifer?_______________________________

3. How much water do you think each of the following would hold?

sand_______________________________________

clay_______________________________________

coal_______________________________________

RAIN AND LEACHING

6-8

SUBJECT:
Chemistry, Earth Science

TIME:
50 minutes

MATERIALS:
For each group of 3-4 students:
1/4 cup topsoil
1/4 Tbsp powdered, red tempera paint
1 funnel
2-L soda bottle
1 coffee filter
1/4 cup water
student sheet

OBJECTIVES

The student will do the following:

1. State what leaching is and how it occurs.
2. Make a model simulating leaching.
3. State the results of leaching.

BACKGROUND INFORMATION

Most of our household waste is buried in landfills. An important factor in how landfills are built is how they contain waste and prevent waste from contaminating nearby soil and water sources. The possibility of leachate contaminating soil and groundwater exists wherever wastes are disposed.

Leachate is a fluid that has passed through or emerged from the waste in a landfill, picking up a variety of suspended and dissolved materials along the way. Leachate generation depends on the amount of liquid originally contained in the waste (primary leachate) and the quantity of precipitation that enters the landfill through the cover or that which comes in direct contact with the waste (secondary leachate) prior to being covered. Factors that affect leachate generation are climate (rainfall), topography (run-on/runoff), landfill cover, vegetation, and type of waste.

In unlined landfills, the leachate continues to leach into the ground and may contaminate groundwater. Many old landfills used a simple clay liner for containing leachate (clay is one of the most non-permeable soils). Newer landfills are required to meet federal and state requirements to prevent environmental contamination (Subtitle D landfills). These landfills have sophisticated liner systems often made of heavy-duty, high density polyethylene (HDPE) plastic, where leachate is routed to a wastewater treatment plant. Treated leachate can be disposed of in a number of ways (e.g., discharged to surface waters or recirculated back into the landfill). Some states also allow continued use of clay liners, if the liner meets federal and state performance standards, and if the leachate is properly collected, treated, and disposed of.

In this lesson, the landfill model represents the construction of a Subtitle D sanitary landfill to hold municipal waste.

A common convenient procedure for disposal of household and domestic garbage is to take it to the nearest ravine, hollow, or back road and leave it in a completely unprotected situation. Because this kind of behavior is such an accepted and uncontested way of life for many households, the effect of this garbage upon water quality can be overwhelming. Often, there is absolutely no regard for the contamination potential of some of these items. The results of this can be the introduction of very toxic substances into the streams and groundwater. An understanding of the long-term harmful effects of these actions would influence the future actions of students and their counterparts toward proper garbage disposal. Such an understanding of the part of the community leaders will possibly influence legislation and enforcement.

Terms

leaching: the removal of chemical constituents from rocks and soil by water.

leachate: the liquid formed when water (from precipitation) soaks into and through soil, picking up a variety of suspended and dissolved materials from the waste.

topsoil: the rich upper layer of soil in which plants have most of their roots.

runoff: water (originating as precipitation) that flows across surfaces rather than soaking in; eventually enters a water body; may pick up and carry a variety of pollutants.

landfill: a large, outdoor area for waste disposal; landfills where waste is exposed to the atmosphere (open dumps) are now illegal; in "sanitary" landfills, waste is layered and covered with soil.

sanitary landfill: rehabilitated land in which garbage and trash have been buried.

ADVANCE PREPARATION

A. Divide the class into groups of 3-4.

B. Gather enough materials for each group to do the investigation twice.

PROCEDURE

I. Setting the stage

A. Discuss what can occur when rain hits the ground: evaporation, runoff, absorption into the ground.

B. Discuss the fact that nutrients in the soil are important for plant growth.

C. Review with students the definition of "leaching."

II. Activities

A. Tell students they will be constructing a model which illustrates leaching.

B. Have each group do the following with their materials:

1. Add 1/4 Tbsp (1.25 mL) red tempera paint to 1/4 cup (75 mL) topsoil. Mix thoroughly.

2. Set funnel in the 2-L bottle.

3. Place the coffee filter inside the funnel.

4. Pour the colored soil into the paper filter.

5. SLOWLY add 1/4 cup (75 mL) of water to the funnel.

6. Observe the liquid dripping into the bottle. **(Teacher Note: Results—The liquid will be red. This red** liquid represents the nutrients in the topsoil which have been leached.)

7. Repeat the process. This time, QUICKLY add 1/4 cup (75mL) of water until the filter is full.

8. Observe the liquid dripping into the bottle.

III. Follow-Up

A. Have the students write up the activity using the student sheet.

B. Ask the students the following questions:

1. What does the red tempera paint represent?

2. What happened to the paint/dirt mixture after water was added?

3. What was the result of the activity?

4. Why did the results occur?

IV. Extensions

A. Research landfills and how they are constructed.

B. Discuss what happens when it rains on an open dump, a landfill, and a sanitary landfill.

RESOURCES

Arms, K., Environmental Science, Holt, Rinehart and Winston, Austin, TX, 1996.

Cunningham, W., and Saigo, B., Environmental Science, Brown Publishers, Dubuque, IA, 1995.

Directions: Complete the following information about your investigation.

1. Problem statement

____

____

2. Procedure (number the steps you performed)

   a.

   b.

3. Data collected

Trial	Observation
Trial 1 Add Water Slowly	
Trial 2 Add Water Quickly	

4. Data analysis

   a. Did the same amount of leachate come out of both trials?

   b. Were the leachates a different color? If so, how were they different?

5. Tentative conclusions

   a. What is the relationship between the rate at which water flows through soil and the amount of leaching?

   b. In which cases would leaching be good?

   c. In which cases would leaching be bad?

MAKING DRINKING WATER

6-8

SUBJECTS:
Chemistry, Earth Science, Health

TIME:
50 minutes

MATERIALS:
For each group:
600 mL water
10 mL teaspoon dirt
2 clear plastic cups (10 oz.)
2 pieces of cheesecloth to cover cup top
20 mL powered alum (from a drug store)
teacher sheets

OBJECTIVES

The student will do the following:

1. Describe methods of purifying water as used by the pioneers, as well as those being used today by water treatment facilities.

2. Explain how groundwater and drinking water can become contaminated.

BACKGROUND INFORMATION

The pioneers learned to drink from flowing waters and not from still waters. While water in lakes, rivers, and streams often contained impurities that made them look and smell bad, the water could be "cleaned" to make it safer to drink. The pioneers used citric acid or alum, which took suspended particles and allowed them to sink to the bottom of the bucket. Sedimentation, or allowing the water to sit for several hours, also took out some impurities. Finally, they would strain the water through material to take out the rest of the impurities. To further purify the water, especially if disease was suspected, they boiled the water before drinking it.

Several of these methods are used by water companies to treat our drinking water today. The water that is processed for most drinking water comes from rivers, lakes, streams, and groundwater and has usually been transferred and stored before processing.

Groundwater accounts for a major portion of the world's freshwater resources. Thousands of cities and towns rely on groundwater for their drinking water. Groundwater can become contaminated from a variety of sources. Because groundwater is such an important source of drinking water, we must be careful not to contaminate it through pollution or careless disposal of household chemicals.

Terms

aeration: exposing to circulating air; addition of oxygen to wastewater or water, as in the step of both activated sludge wastewater treatment process and drinking water treatment.

coagulation: the process by which dirt and other small suspended solid particles are chemically bound, forming flocs using a coagulant (flocculant) so they can be removed from the water (the second step in drinking water treatment).

chlorination: the addition of chlorine to water to destroy microorganisms, especially for disinfection.

filtration: the process of passing a liquid or gas through a porous article or mass (Example: paper, membrane, sand) to separate out matter in suspension, used in both wastewater and drinking water treatment.

sedimentation: (1) the process of depositing sediment, or the addition of soils to lakes that is part of the natural aging process; (2) the drinking water treatment process of letting heavy particles in raw water settle out into holding ponds or basins before filtration (also called "settling"); (3) the process used in both primary and secondary wastewater treatment that takes place when gravity pulls particles to the bottom of a tank (also called "settling").

ADVANCE PREPARATION

A. Make transparencies of the teacher sheets or run off copies for each group.

B. Collect sets of materials for each group.

C. On the day prior to the activity, at the beginning of the class, mix 275 mL water and 10 mL of dirt in a clear plastic cup. Note rate of settling during class and let settle overnight.

PROCEDURE

I. Setting the stage

A. Find out if groundwater is used for the community's drinking water.

B. Discuss groundwater with the students and show the transparencies. Discuss what your state uses for drinking water.

C. Discuss water purification and what your community does.

II. Activity

A. Give each group a set of materials.

B. Have the students mix 275 mL water and 10 mL of dirt in a clear plastic cup.

C. Have the students mix 10 mL teaspoon of alum into the water and watch the floc form.

D. Tell the students to allow the cup to sit undisturbed for several minutes, noting the rate of flocking.

E. Discuss the process of sedimentation while the materials are flocking.

F. Have the students cover the clean cup with cheesecloth and carefully pour the flocked water into the cup.

G. Ask the students to clean the first cup and repeat the process with the water and a new piece of cheesecloth.

H. Observe the differences in the material that was collected on the two pieces of cheesecloth.

III. Follow-up

A. Discuss how the final process for pioneers would be boiling, whereas today we use chemicals to purify drinking water.

B. Have the groups of students compare the results they obtained.

IV. Extensions

A. Repeat the investigation using different amounts of dirt and water.

B. Visit a water treatment facility and find out about water purification processes.

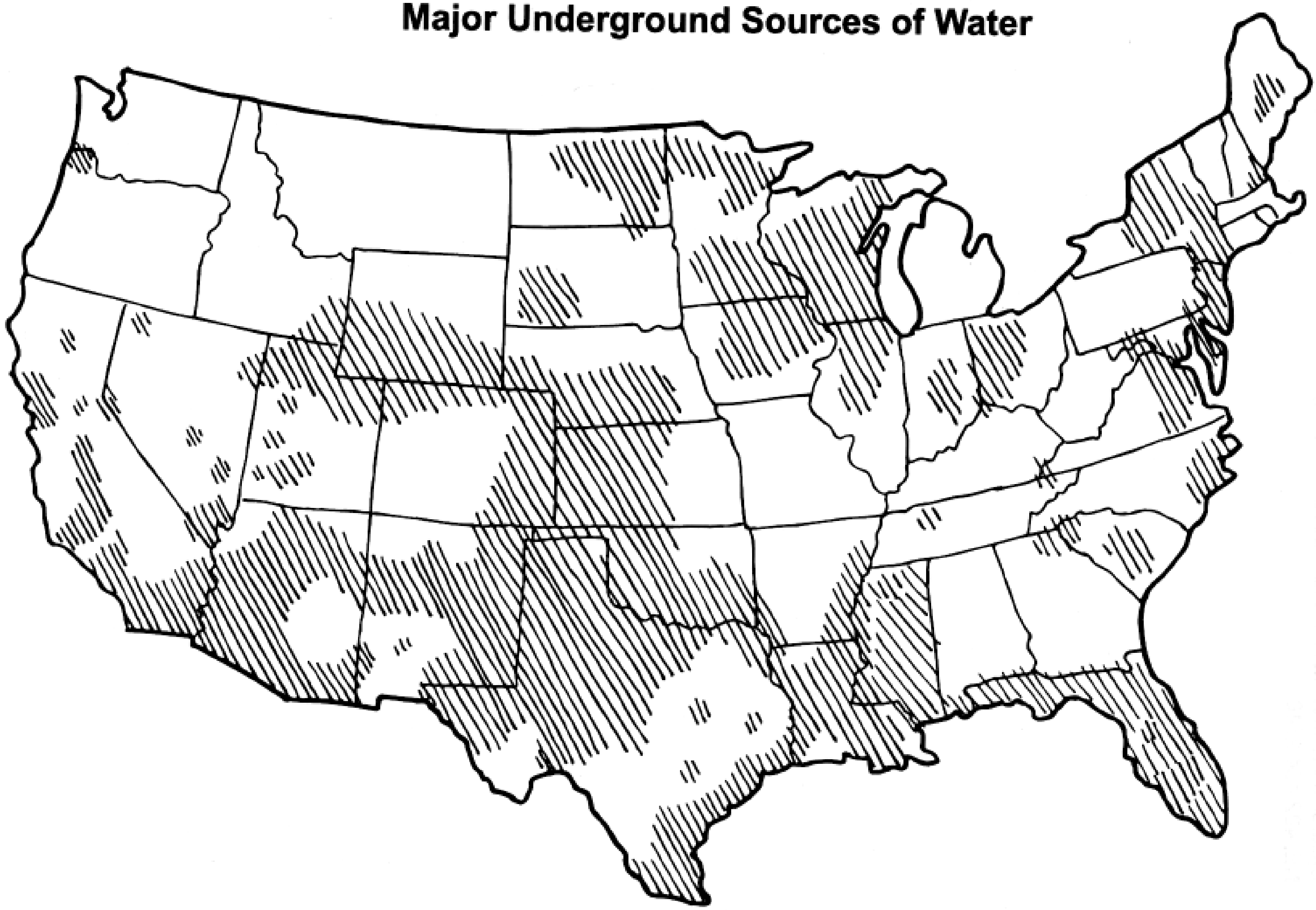
C. Find out what other countries use to purify their drinking water.

D. Interview a soldier or someone who spent time in an area where drinking water had to be purified by using alum.

RESOURCE

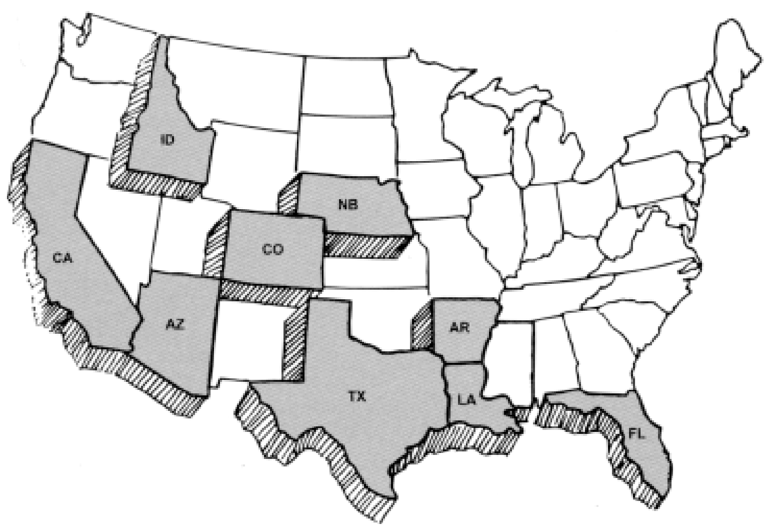
Children's Groundwater Festival Outreach Packet, the Groundwater Foundation, POB 22558, Lincoln, NE, 402-434-2740.

Major Underground Sources of Water



Ten states that rely most on groundwater as a source of water (percentage of all water used which is groundwater):

Iowa	85%	Oklahoma	56%
Texas	61%	Minnesota	54%
Nebraska	59%	South Dakota	48%
Delaware	59%	New Mexico	47%
Arizona	58%	Georgia	41%



Ten states that use the most groundwater (in GPD-Gallons Per Day):

California	14,6000,000,000	Arizona	4,200,000,000
Texas	9,700,000,000	Florida	3,800,000,000
Nebraska	7,100,000,000	Colorado	2,800,000,000
Idaho	6,300,000,000	Louisiana	1,800,000,000
Arkansas	4,300,000,000	Mississippi	1,500,000,000

RECHARGE AND DISCHARGE OF GROUNDWATER

6-8

SUBJECTS:
Geology,

TIME:
50 minutes

MATERIALS:
For each group:
clear plastic container (at least 15cm x 22cm x 6 cm deep)
enough pea-size gravel to fill container 2/3 full
two 472 mL paper cups
one pump dispenser
472 mL water
grease pencil
twigs or small tree branches
ruler with cm
colored powered drink mix or food coloring (optional)
teacher sheet

OBJECTIVES

The student will do the following:

1. Identify several sources of recharge and discharge for groundwater.

2. Discuss how water moves from recharge to discharge areas.

3. Discuss the connection between surface water and groundwater.

4. Explain how groundwater can become polluted.

BACKGROUND INFORMATION

Approximately half of the people living in the U.S. depend on groundwater for their drinking water. Groundwater is also one of the most important sources of irrigation water. Unfortunately, some of the groundwater in every state has become tainted with pollutants. Some scientists fear that the percentage of contaminated groundwater may increase as toxic chemicals dumped on the ground during the past several decades slowly make their way into groundwater systems.

Many people picture groundwater as underground lakes or rivers, but, it is actually water that fills the spaces between rocks and soil particles underground—much the same way water fills a sponge. Most groundwater is precipitation that has soaked into the ground. Groundwater sometimes feeds lakes, springs, and other surface water.

Recharge is the addition of water to an aquifer. Recharge can occur from precipitation or from surface water bodies such as lakes, rivers, or streams. Water is lost from an aquifer through discharge. Water can be discharged from an aquifer through wells and springs, and to surface water bodies, such as rivers, ponds, and wetlands.

Terms

aquifer: porous, water-bearing layer of sand, gravel, and rock below the Earth's surface; reservoir for groundwater.

groundwater: water that infiltrates into the Earth and is stored in usable amounts in the soil and rock below the Earth's surface; water within the zone of saturation.

groundwater discharge: the flow or pumping of water from an aquifer.

groundwater recharge: the addition of water to an aquifer.

infiltration: the flow of water downward from the land surface into and through the upper soil layers.

permeability: the capacity of a porous material to transmit fluids. Permeability is a function of the sizes, shapes, and degree of connection among pore spaces, the viscosity of the fluid, and the pressure driving the fluid.

saturated zone: a portion of the soil profile where all pores are filled with water. Aquifers are located in this zone. There may be multiple saturation zones at different soil depths separated by layers of clay or rock.

surface water: precipitation that does not soak into the ground or return to the atmosphere by evaporation or transpiration. It is stored in streams, lakes, rivers, ponds, wetlands, oceans, and reservoirs.

unsaturated zone: a portion of the soil profile that contains both water and air; the ozone between the land surface and the water table. The soil formations so not yeild usable amounts of free-flowing water. It is also called zone of aeration and vadose zone.

water table: upper surface of the zone of saturation of groundwater.

ADVANCE PREPARATION

A. Using a nail, punch 8 - 10 small holes in the bottom of the paper cups. When filled with water, this will simulate rain.

B. Gather materials and fill the clear containers 2/3 full with the gravel. The gravel should be level in the containers.

C. Make transparency or run off copies of teacher sheet showing model set up.

PROCEDURE

I. Setting the stage

A. Discuss groundwater and the reasons why people depend on it.

B. Discuss what your community uses for drinking water.

II. Activity

A. Divide the class into groups and distribute the materials.

B. Have students construct the model as shown with a valley in the middle. Explain that the gravel mounds on both sides of the container represent hills with a valley in between. Use the twigs to represent trees and vegetation.

C. Have one student fill the cup without holes with water then pour this water into the cup with holes holding it over one of this “hills” of the model. Observe how the water moves through the gravel.

D. Introduce the word “recharge” - the addition of water to the groundwater system. Have students observe that water is standing in the valley. Have the students use the grease pencil to draw a line identifying the water level under the hills and in the valley. Measure the height of the water and mark it on student diagrams of the model.

E. Explain that they have just identified the top of the groundwater in their model. The top of the groundwater is called the water table. Discuss how the groundwater becomes a pond in the valley because the water table is higher than the land surface.

F. Have students insert the pump into one of the hills on the side of the valley pushing the bottom down to the groundwater. Allow each of the students in the group to press the pump 20-30 times after the water in the pump has begun to flow. Catch the water in the cup with no holes.

G. After each student pumps the water, mark the level of the water with the grease pencil and measure it. Mark the level of the diagram.

III. Follow-Up

A. Have the students work as a group to fill in the student sheet. Have them discuss their answers as a class.

IV. Extensions

A. Sprinkle the colored powder drink mix or food coloring on top of one of the hills and repeat the activity. Discuss the movement of “pollution” from the hill to the groundwater to the pond.

B. Try the activity with sand and gravel of a different size and note the rate of recharge.

RESOURCES

U.S. Geological Survey, Box 25286, Denver Federal Center, Denver, CO 80225, 303-236-7477.

The Groundwater Foundation, P.O. Box 22558, Lincoln, NE 68542, 404-434-2740.

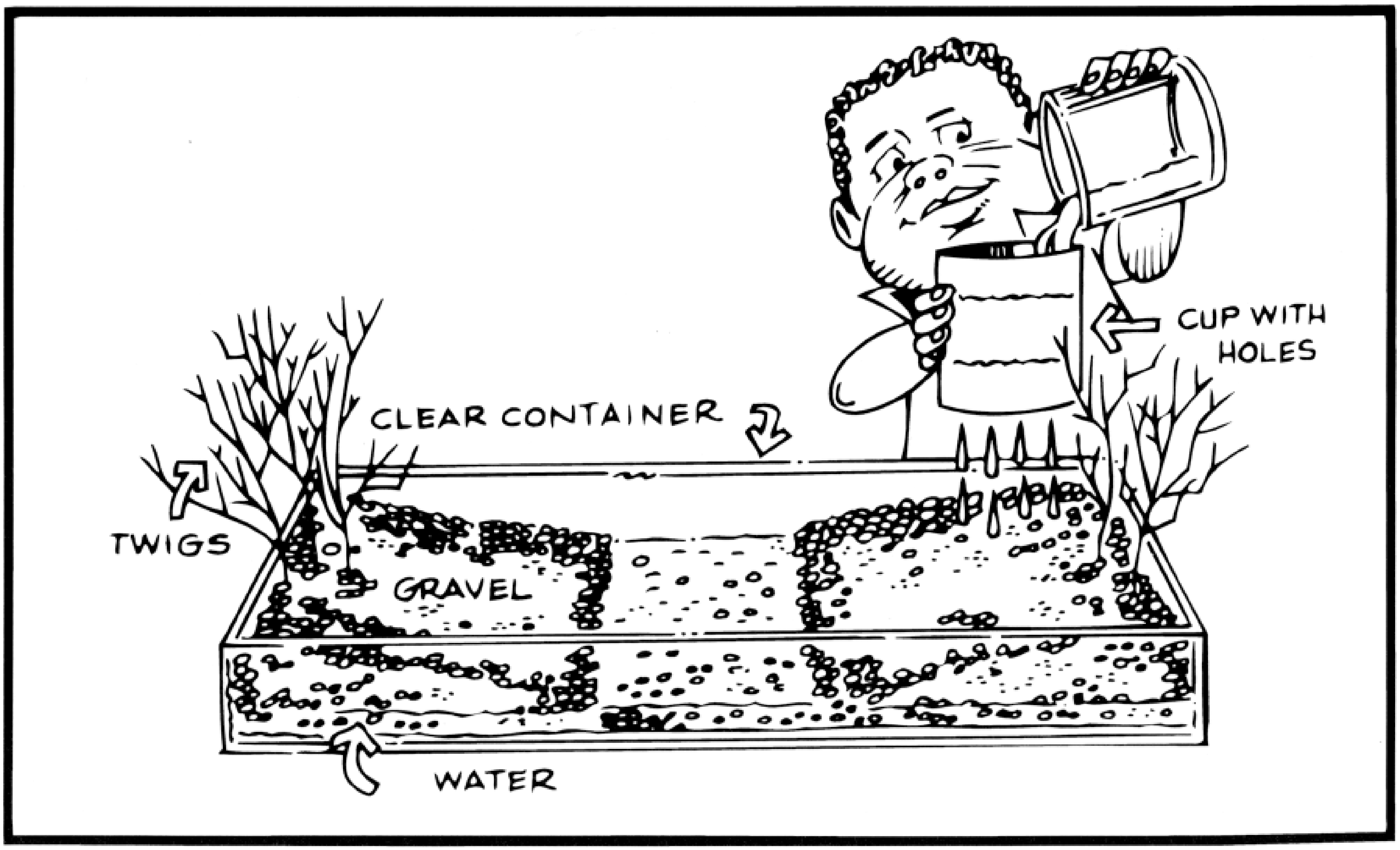
STUDENT SHEET RECHG. AND DISCHG. OF GROUND H2O

6-8

Directions: Draw a diagram of your model in the space below. Make it at least 8cm high. You will be measuring the level of water in your model and marking it on your diagram.

Answer these questions as a group. Be prepared to discuss them with the class.

1. What was the highest level (in cm) of your groundwater? _______________
2. What was the level after one pumping? _____________________________
3. What was the level after two pumpings? ____________________________
4. What was the level after three pumpings? ___________________________
5. Where does groundwater come from?
6. What could happen to groundwater if a well is drilled nearby?
7. Explain how groundwater can become polluted by human activity.
8. Devise a way to clean up polluted groundwater.


CUP WITH HOLES
CLEAR CONTAINER
TWIGS
GRAVEL
WATER

RURAL WASTEWATER

6-8

SUBJECTS:
Biology, Health

TIME:
2 class periods

MATERIALS:
For each lab station:
funnel
rubber tubing
glass bend
pneumatic trough
3 "T" connectors
250-mL side arm flask
1-hole stopper
wire gauge
coarse gravel
fine gravel
soil
Lamotte Water Test Kit (available through a biological supplies catalog)
student sheets

OBJECTIVES

The student will do the following:

1. Distinguish between aerobic and anaerobic digestion of waste.
2. Explain the difference between black water and gray water waste.
3. Explain how a septic tank drainage field system is constructed and functions.
4. Describe the symptoms of a failing septic system.
5. Explain how a failing septic tank system can cause groundwater contamination.

BACKGROUND INFORMATION

Many rural areas are not served by any type of wastewater systems, and household wastewater must be disposed of onsite. The septic tank, along with a soil absorption system (field lines), is the most common and effective method of wastewater treatment used in these rural settings. Cesspools, which are no longer approved for new installations in most areas, and pit privies are the other most widely known methods.

Other alternatives include the following: aerobic (requiring oxygen) treatment tanks; off- lot systems in which wastewater from several households is conveyed to a common disposal and treatment site (such as a soil absorption field); and evapotranspiration systems. Evapotranspiration is a process used for shallow soil depths. Grass or other plants are used to cover the field which receive the wastewater. The plants take the water and selected mineral but leave the rest for organic decomposition. The water leaves the plants by normal transpiration processes by which plants lose water to the air. Some of the more recent alternatives include the following: composting; low-flush; incinerating, or recycling toilet systems; and dual treatment systems which separate "blackwater" (human body wastes) from "graywater" (other domestic wastewater). On-site disposal systems, such as septic tanks, discharge wastewater to the subsurface.

A septic tank is simply a tank buried in the ground for the purpose of treating the sewage from an individual home. Wastewater flows into the tank where bacteria breakdown organic matter, allowing cleaner water to flow out of the tank, into the ground, through a subsurface drainage system. Periodically, sludge or solid matter in the bottom of the tank must be removed and disposed. Failing septic tanks and cesspools are frequent sources of groundwater contamination.

<u>Terms</u>

aerobic: in the presence of oxygen.

anaerobic: in the absence of oxygen; oxygen free.

sewage: the solid human waste and human-generated wastes that are normally discharged into wastewater transported through sewers.

sludge: solids removed from wastewater or raw water in the process of treatment; the heavy, partially decomposed solids found in the bottom of a septic tank.

evapotranspiration: molecules leaving the liquid state and entering the vapor or gaseous state through plant leaves.

blackwater: sewage that is from the solid human waste.

graywater: all sewage that does not contain solid human waste that comes form a household, (Examples: from sinks, laundry, and showers.

ADVANCE PREPARATIONS

A. Copy student sheets

B. Gather materials and put out at each station (only one water test kit is necessary for the class).

C. Prepare “blackwater” by adding to containers of tap water such materials as barn- yard animal manure or animal manure purchased from a garden shop. Prepare “gray water” by adding to container of tap water such materials as raw peanut hulls, ashes from burned peanuts, detergent, or grease.

II. Activities

A. Have students make working septic tank models.

B. Run “wastewater” into the septic tank (flash) until it rises to the outlet. Allow at least 24 hours (or a weekend) at room temperature. One group runs “blackwater” through the system and one runs “graywater” through the system.

C. After observing results of previous work, add an amount of the same type of “wastewater” to the septic tank (flask) and catch any effluent coming from the drain tubing. (A pinch clamp should be used on the tubing.)

D. Test final effluent for pH, odor, mineral content (hardness), color, and turbidity.

E. Have students compare effluents of wastewater types.

III. Follow-Up

Have the students complete the following:

A. Explain the difference between aerobic and anaerobic decomposition of wastes.

B. Define “blackwater” and “graywater.”

C. Explain how a septic tank is constructed.

D. Explain how to install a drainage field system.

E. List ways of abusing a septic tank system.

F. Describe several symptoms that indicate that the septic tank system is failing.

IV. Extensions

A. Construct diagrams and specifications of systems for wastewater treatment making use of 1) an aerobic treatment tank and 2) evapotranspiration. After doing so, have students discuss the following questions:

1. What factors limit the volume of wastewater that can be processed?

2. Is each system equally effective in swampy and hilly terrain?

3. How does each system treat wastewater so as to avoid offensive odors?

4. Discuss which system would work best in rural areas. What type of system is used by the schools? Where is the system and drainage field for the school located?

B. Have students do a “perk” test on the soil in the area. (See your local health department for instructions on how to perform this activity.)

C. Have rural students check the site of effluent discharge from the systems at their homes in relation to the drinking water source. Is it adequate? What are the regulations for location of waste treatment systems?

D. Have students explore problems created by concentrated housing (mobile home/trailer parks along a lake) when only a septic tank system is used for each habitat.

RESOURCE

Alabama Cooperative Extension Service, Auburn University, Auburn, AL 36849.

ALABAMA COOPERATIVE EXTENSION SERVICE, AUBURN UNIVERSITY, ALABAMA 36849-5612

CIRCULAR ANR-790 Water Quality

On-Site Sewage Treatment

Understanding Septic System Design And Construction

Years of experience have shown that properly designed, constructed, and maintained septic systems pose no undue stress on the environment. All three tasks—design, construction, and maintenance are crucial if the system is to operate properly.

Typically, the homeowner does not become involved in the design details of a septic system. State and local regulations and design standards have been established to ensure properly designed systems. Similarly, if homeowners are careful in selecting a reputable construction contractor, they usually can be assured that the system will be installed properly.

But understanding septic system design and construction will enable homeowners to interact knowledgeably with local inspectors and contractors.

Conventional Septic System Design

Conventional septic systems have two key components: a septic tank and a soil absorption system. Each must function properly for the entire system to perform satisfactorily.

The Septic Tank.

The septic tank is simply a container usually prefabricated from concrete according to standard designs. It receives wastewater from the home generated in the bathroom, kitchen, and laundry. The septic tank retains the wastewater for approximately 24 hours allowing the solids to separate and settle out and allowing bacteria to partially decompose and liquefy the solids.

There are three layers in the septic tank:

1. Sludge, consisting of heavy, partially decomposed solids that will not float.
2. Liquid, containing dissolved materials such as detergents and small amounts of suspended solids.
3. Scum, consisting of fats and oils and other light-weight solids that float on the surface of the wastewater.

Solids and scum in the tanks are digested or decomposed by anaerobic bacteria (bacteria active in the absence of oxygen). This decomposition liquefies up to 50 percent of the solids and scum. The liquid is carried out into the absorption field, and the indigestible solids remain in the tank as sludge.

Each time raw sewage enters the tank, an equal amount of fluid is forced out of the tank. Tees or baffles at the inlet and outlet of the tank slow the velocity of incoming wastewater and prevent flow directly to the outlet of the tank. The tees also help prevent sludge from leaving the tank through outlet lines. The fluid leaving the tank is called effluent and can contain disease organisms. Small amounts of suspended and dissolved matter in the effluent not completely stabilized or digested also move out of the tank to the absorption field.

While typically designed to hold 1,000 gallons of liquid, the size of the septic tank varies, depending on the number of bedrooms in the home. Regulations require that septic tanks be a certain size based on the expected daily flow rate of wastewater. Proper sizing is important to allow adequate time for settling and flotation so that the soil absorption system is not clogged with sludge and scum.

The Soil Absorption System

The soil absorption system consists of a distribution box and up to 300 feet or more of tile or plastic drain lines buried in the soil. The soil absorption system receives wastewater from the septic tank. The partially treated liquid, called effluent, flows out of the septic tank to the distribution box, where it is evenly distributed throughout the absorption field. The effluent is allowed to trickle into the soil through perforated pipes placed at a certain depth throughout the absorption field. As effluent moves through the soil, impurities and pathogens are removed. The soil provides filtering and treatment to remove pathogenic microorganisms, organics, and nutrients from the wastewater. Just as the septic tank requires a certain amount of time to allow solids to settle and light materials to float, so the soil requires a certain amount of time to remove harmful materials from the wastewater leaving the tank.

The size of an absorption area is based on the volume of wastewater generated in the home and the permeability of the soil. Usually, the absorption field can fit within the front yard or the backyard of a typical 1-acre homesite. The precise area requirements will depend upon the kinds of soils at the homesite, the size of the house (the number of bedrooms), and the topography of the lot. Adequate land area must be available to install a replacement system in case it is ever needed. This replacement area must meet the same soil and site requirements as the original system.

Conventional Septic System Location

Unlike a sewer system, which discharges treated wastewater into a body of water, the septic system depends on the soil around the home to treat and dispose of sewage effluent. For this reason, a septic system should be installed only in soils that will adequately absorb and purify the effluent. In addition, the septic system must be located a specified distance from wells, surface waters, and easements.

To insure that your septic system is located properly, keep the following tips in mind:

1. The septic system should be installed where the soil tests were performed.

2. The location of individual septic system components should meet certain setback requirements. If a septic system is located too close to wells, streams, or lakes, wastewater may not be properly filtered and may contaminate surface water supplies. Generally accepted safe distances are shown in Table 1.

When the septic system is being installed, record the location of your septic tank, absorption field, and repair area. Measure and record distances from the septic tank, septic tank cleanout, and soil absorption system to above ground features such as buildings, fence comers, or large trees. Then after the area has grassed over, you can still find the system. A sample sheet for recording information is provided on another page.

Table 1. Recommended Horizontal Separation Distances For On-Site Sewage Disposal System Components.*

Part Of System	Water Supply (well or suction line)	Water Supply (pressure line)	Lake Or Stream	Dwelling	Property Line
	Feet				
Septic tank	50	30	50	10	10
Distribution box	50	30	50	20	10
Absorption field	100	30	50	20	10

*Distances may vary from state to state. Contact your local health department for specific guidelines.

Conventional Septic System Construction

While the construction of a septic system is a matter for professionals, homeowners can ensure proper construction by keeping the following tips in mind.

Keep heavy equipment off the soil absorption system area both before and after construction. Soil compaction can result in premature failure of the system. During construction of the house, fence off the area designated for the soil absorption system as well as the required placement area and the area directly downhill.

Water related issues are given below:

- Avoid installing the septic tank and soil absorption system when the soil is wet. Construction in wet soil can cause puddling and smearing and increase soil compaction. This can greatly reduce soil permeability and shorten the life of a system.
- Make sure the perforated pipes of the absorption system are level to provide even distribution of the septic tank effluent. If settling and frost action cause shifting, part of the soil absorption system may be overloaded.
- Divert rainwater from building roofs and paved areas away from the soil absorption system. This surface water will increase the amount of water the soil has to absorb and cause premature failure.
- Keep water from footing drains and water softener discharges out of the septic system. Water from footing drains can overload the capacity of the absorption field, reducing its ability to accept effluent. Water softener discharges contain high concentrations of sodium, which react with the soil to reduce permeability. Remember, the system was designed and sized to handle only the wastewater from plumbing fixtures and washing machines.

Do not plant trees and bushes near the septic tank or absorption field because their roots can enter the system and cause extensive clogging problems. Do not cover the absorption field with a driveway, patio, or other paving that would prevent the release of water vapor.

Allow accessibility for a pumper truck or backhoe to service your system. Septic tanks require routine pumping and periodic maintenance, so keep access to the area easy.

Alternative On-Site Sewage Treatment Systems

In locations where a conventional septic tank and soil absorption system is unsuitable (such as areas with high water tables or slowly permeable soils), you may be able to modify site conditions. For example, in areas with high water tables one option is to use underdrains or curtain drains to lower the water table. Another option is to raise the level of the soil surface with layers of fill soil.

When it is not practical to modify the site, consider an alternative system. The mound system and the aeration system are alternatives that may be used in areas with high water tables or slowly permeable soils.

With the mound system, the absorption field is built above the natural ground level. A distribution network supplies effluent to the mound, and the effluent is treated as it passes through the fill sand and natural soil.

The aeration system consists of a chamber that mechanically aerates (mixes air with) the effluent and decomposes the solids. Effluent is discharged to an absorption field or, after chlorination, to surface water or an evaporation pond.

Other alternatives include sand filters, lagoons, constructed wetlands, electro-osmosis systems, dropbox distribution systems, serial distribution systems, pressure-dosed distribution systems, and leaching chambers.

In general, alternative systems are more costly to install and operate than conventional septic tank and soil absorption systems and may require additional maintenance.

Conclusion

Improperly designed and constructed septic systems are doomed from the start. These systems usually fail in a few months because they are inadequately sized, installed in impermeable soils, or not properly constructed.

When on-site sewage disposal systems are installed on the proper site and are properly designed, constructed, and maintained, they provide a safe, cost-effective alternative to municipal and community sanitary sewage treatment.

References

Alabama Department Of Public Health. 1988. Location of On-Site Sewage Disposal Systems. Rules of State Board of Health. Chapter 420-3-1-. 22. Division of Community Environmental Protection. Onsite Sewage Branch. Montgomery, AL.

Bicki, Thomas J. 1989. Septic Systems: Operation And Maintenance Of On-Site Sewage Disposal Systems. Land And Water Number 15. Illinois Cooperative Extension Service. University of Illinois at Urbana-Champaign, IL.

Graham, Frances C. 1990. Correct Use Of Your Septic Tank. Information Sheet 1419. Mississippi Cooperative Extension Service. Mississippi State University. Mississippi State, MS.

Septic System Installation Record

Date installed: ____

Building permit number: ____

Name and address of licensed installer:

____

____

____

Size of septic tank: ____ gal

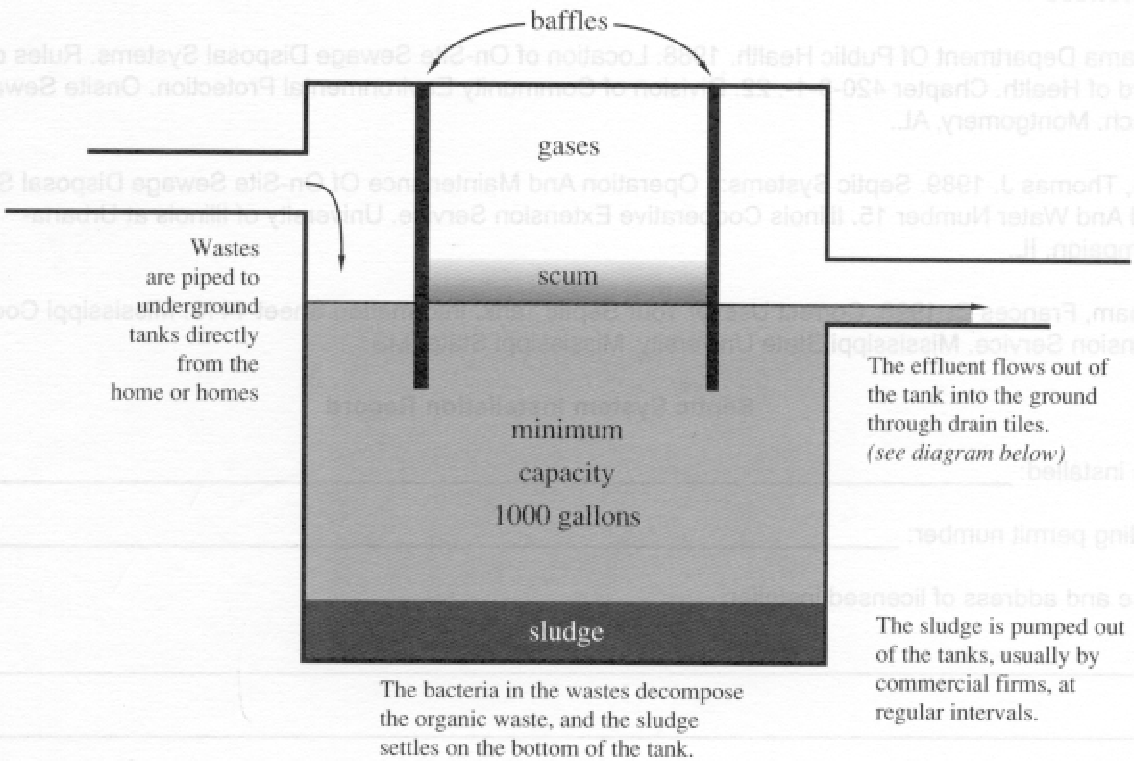
Amount of field lines: ____ ft

Depth of trenches or bed: ____ ft

Sketch the layout of your septic system. (Include the distances from the tank and the absorption field to buildings and wells.)

Septic Tanks

Septic tanks are used for domestic wastes when a sewer line is not available to carry them to a treatment plant.



Aerial View of Drain Tiles